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1724

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Commissioner of Patents,
PO Box 1450
Alexandria, VA 22313-1450

7 May 2004

Dear Sir,

PARTIAL RESPONSE TO OFFICE ACTION

Serial Number: 09/872,990
Confirmation Number: 3149
Applicant: WARD, Owen P. et al.
Title: TREATMENT OF SEWAGE SLUDGE
Date of Filing: 31 May 2001
Examiner: HRUSKOCI, Peter A. Art Unit: 1724
Our file Ref: 437-01US

This is in partial response to the Office Action dated 09 December 2003.

Included herewith is Declaration by Dr Owen Ward. The Declaration is accompanied by a photocopy of a Graph, a sheet of Photographs, and a copy of Dr Ward's Career Profile. The other portion of the Response will follow shortly.

Submitted by,

Anthony Asquith
(Regn 32373)
Agent for the Applicant

Encl:
Declaration, with inclusions

in Fed Ex 8460 4644 4646

US.Pat.Apl.Nr: 09/872,990 Attorney's Docket: 437-01US
Title: Treatment of Sewage Sludge
Inventors: O.P.Ward + H.Burd
Assignee: Lystek Int'l

Declaration of Dr Owen P. Ward

1. I am the Owen P. Ward named as co-inventor in the above-identified patent application.

I am Chief Scientist of Lystek International, Inc., owner of the patent rights.

2. I am now, and have for 18 years been, a professor in the Department of Biology at the University of Waterloo, in Canada. My field is biochemistry and microbiology. One of my specialities is the biochemistry of the treatment of sludges. A copy of my Career Profile is included herewith.

3. I attended an interview with examiner Peter Hruskoci at the USPTO on May 5, 2004. My main purpose in making this Declaration, arising from that interview, is to explain and justify the numerically-expressed limitations as recited in claim 1 of the above patent application.

4. Hitherto, high-solids-content sludge has been regarded as un-pumpable. We have discovered that high-solids-content sludge can very cost-effectively be transformed from un-pumpable to pumpable. Our key to making this transformation is a synergy of a number of elements. That is to say, we have found we can transform high-solids-content sludge from non-pumpable to pumpable if we shear the sludge while the sludge is hot (i.e at incubation temperatures) and while the sludge is at high-pH.

Defining when this synergy occurs is a matter of defining numbers.

5. Lower limit of solids-content

It can be regarded that sludge is non-pumpable if it has a higher viscosity than e.g a light motor oil, which occurs if the sludge has a higher-than-ten-percent solids-content.

However, although the viscosity of sludge can be compared, as a number, with the viscosity of motor oil, of course the two substances have a quite different "feel". Sludge is viscous because its liquid (water) contains particulate solids in suspension, not because it is a thick sticky liquid, as such, like oil. The usual ways of measuring viscosity are based on the time it takes for a fixed volume of the liquid in question to pass through an orifice -- a measurement which takes

no account of the "feel" of the substance being measured.

Thus, although oils more viscous than light motor oil are easily pumpable, sludges more viscous than light motor oil have been, and are, regarded as non-pumpable (referring, of course, to the sludge in its raw, i.e not-yet-treated, state). This difference between pumpability and non-pumpability of sludge occurs at a viscosity of about 20,000 centipoise, which occurs at a solids-concentration of about ten (weight)percent.

The attached sheet of photographs illustrate the effect of the invention. The upper view shows, on the left, a body of 3%-solids sludge, which is clearly a liquid, being only a little more viscous than water. In the centre is a body of 15%-solids sludge. This material is basically cake -- it "stands up on its own" -- and is completely non-pumpable. On the right is the same 15%-solids material after it has been through the process of the invention.

The centre view illustrates the pourability of the 3%-solids sludge. (Pourability may be regarded as the same as pumpability for the purpose of the illustrations.) The bottom view illustrates the pourability of the treated 15%-solids sludge. Now, the 15%-solids sludge has been transformed, and it is pourable, like a liquid, and indeed it is almost as pourable as the 3%-solids liquid on the left.

Hitherto, the general rule has been that, if a raw sludge is non-pumpable because it has a solids-content above ten percent, really the only way to make it pumpable is to add water -- i.e to increase the water-content of the sludge -- thereby bringing the solids-content down below ten percent.

Consider the attached graph/diagram that plots viscosity as a function of solids-content. To be noted especially is the sudden huge change in viscosity that occurs around ten percent solids-content. Both the suddenness and the size of the change are especially to be noticed. It is a "chalk and cheese" comparison: comparing below-10% sludge with above-10% sludge is like comparing water with tar.

Our invention only applies to the high-solids-content sludges. At a solids-content below ten percent, the viscosity is already so low that no steps need be taken to make it pumpable. In other words, combining shearing with high temperature and high pH will not make any difference to the pumpability of low-solids-content biological sludge. (However, those things do make the already-pumpable sludge marginally less viscous -- which is marginally worthwhile.)

Considering the attached graph, the difference between "high" and "low" solids-content, though marked, is not a sudden step: inasmuch as a bottom limit has to be expressed for our invention, being a statement of a figure of solids-content below which the invention is pointless, it is our position that the bottom limit is a sludge that contains ten percent solids by weight.

6. Upper limit of solids-content

As to an upper limit, it should be noted that of course it is possible for a sludge to be so thick that no amount of treatment of the sludge will make it pumpable. In that case, the operators will

have to add water to the sludge. The problem with adding water is the cost -- not of the water itself, but of the energy required to heat the water, the extra quantities of alkali needed to raise the pH, and the extra costs of trucking and pumping the sludge given its increased volume.

The operators want to have the solids content as high (and the water content as low) as they can get away with. The solids are the payload -- not the water. Thus the upper limit is the practical limit, that the solids-content should be as high as possible, consistent with the sludge being pumpable. The main benefit of the invention is that it enables higher solids-content sludges to be transformed into pumpable than has been the case hitherto -- but of course in practice there is still an upper limit. In the case of a particular sludge, the operators might care to experiment with the levels of the parameters, as noted in our specification, until a combination is reached in which the sludge has as high a solids content as possible, but is still pumpable.

7. Upper limit of pH

It is well known that one way of reducing the viscosity of sludge, and at the same time destroying the pathogens in the sludge, is to increase the pH of the sludge to about 12. This is done by adding lime (calcium oxide or hydroxide), soda, potassium hydroxide, etc. One point to note is that it takes a much greater mass of salts to raise the pH from e.g 11.5 to 12 than it takes to raise the pH from 8.5 to 9. As the sludge reaches the 12 pH level, the mass of salt needed to raise it further becomes very significant. Thus, only having to raise the pH to 11.5, rather than to 12, although apparently not a large difference, is in fact a very significant saving. The salts cost money, and there are the associated costs of handling the bulk materials. There is environmental pressure not to include sodium in materials that will be spread on agricultural land, and the move away from sodium salts also adds to the expense.

We have found that we can stop well short of pH 12, and still get very effective improvement in viscosity. In many cases, we have found we can transform high-solids sludge from non-pumpable to pumpable (and kill the pathogens) without going above pH 10 (provided, of course, that we procure the synergy of the combination of pH//temperature//shearing, as described.) We have found that even in the worst cases there is no need to go above 11.5.

It is our position that, if the operators find they have to go above a pH level of 11.5, then they cannot be practicing the invention. They must be mis-applying one of the other parameters that have to be present in our synergistic combination. It is also our position that, if a pH of 11.5 will not transform a particular sludge from non-pumpable to pumpable, then raising the pH even further, i.e above 11.5, will not make any difference.

We have found that we can usually get away with a pH of only 10 or 10.5.

8. Lower limit of pH

There must be some raising of the pH, however. If the pre-treatment sludge is in fact non-pumpable, it will always be necessary to raise the pH to at least 9.5. If the pre-treatment sludge is already pumpable, then a lower pH may be used -- but this invention is restricted in its

applicability to those cases where the untreated sludge is non-pumpable. When the pre-treatment sludge is non-pumpable, the general rule is that the synergy required in the invention will not start to arise unless the pH is above 9.5. In most cases, as mentioned, the pH will need to be 10 or 10.5.

It may be noted that, in the prior systems for treating sludge, the pH of 12 was not just reached, but had to be maintained. In the invention, so long as the pH reaches the required value at some point, that will suffice. (The cost of maintaining a volume of sludge at a high-pH can be almost as much as the cost of bringing the sludge up to the high-pH.)

9. Lower limit of temperature

Traditionally, sludge is incubated, both to reduce viscosity and to kill pathogens. We have found as a general rule that, by engineering the synergy of our combination of pH//temperature//shearing, as described, we need not take the temperature so high as has been the case hitherto, although sometimes we do have to go to temperatures that were common in the traditional systems. The point is this, that generally we can subject a particular sludge to a lower temperature than would traditionally have been used on that sludge, to kill the pathogens. And, in our invention we not only kill the pathogens -- we also transform the sludge from non-pumpable to pumpable.

Temperature costs money, and the operators will seek to get away with the lowest temperature they can. We have found that we usually have to go to temperatures of 60 or 70 degC, in order for our synergistic effect to take place. It is our position that our synergistic effect cannot start to take place unless the sludge is raised above at least 40 degC. Basically, any sludge that can be treated at temperatures below 40 degC did not need our treatment.

10. Upper limit of temperature

The upper limit of temperature will usually be determined by the operators' natural desire to keep the temperature as low as they can get away with. We note that, if, in the case of a particular sludge, our synergistic combination has still not proved efficacious at a temperature of 100 degC, going above 100 degC will not make any difference.

Indeed, as shown in Example VII in our specification, we have found that it can happen that the viscosity of the sludge actually starts to rise again as we take the temperature of the sludge above 70 degC. (We have also found a corresponding tendency for viscosity sometimes to rise again if the pH is taken above 12.)

11. Shearing

The shearing operation has to be done vigorously enough, and for long enough, to bring about the transformation of the sludge. It is our expectation, using the kind of shearing blades and drivers traditionally available for shearing sludge, that in practicing the invention the operators will need to carry on shearing for a period of about ten minutes. Of course, the shearing

apparatus must be sized and powered appropriately to treat the whole volume of sludge, but these matters are well within the competency of designers of such machinery. Assuming all the other elements of the synergistic combination are in place, the shearing operation will usually take no more than about ten minutes. Again, the operators will be disposed to break off shearing as soon as they can, since shearing sludge consumes a good deal of energy. And again, if shearing has not transformed the sludge after a period such as ten minutes (assuming the apparatus has been sized appropriately to the volume of sludge being treated), further shearing is not likely to make much difference.

12. The synergistic effect of the pH//temperature//shearing combination

It is well known among sludge processing experts that the viscosity of sludge can be reduced by raising the sludge's temperature, by raising its pH, and by shearing it. Each of these steps can be expected to have a more or less marginal effect on viscosity. That is to say, when each step is applied, it will make a (below-10%) sludge a little more easily pumpable. In sludges that have less than ten percent solids, there is no synergistic effect to combining the pH-temperature-shearing steps. Each step, if added, merely makes its own contribution; and the whole is no more than the sum of the parts.

It has not previously been realised that the combination would have a synergistic effect when applied to sludges having more than ten percent solids. No-one realised that the combination would make enough of a difference to the viscosity of a high-solids sludge to transform the high-solids sludge from non-pumpable to pumpable.

The traditional constraint has generally been understood to be that the only way of making a significant effect on the pumpability of high-solids sludge is to make a significant increase in water content -- i.e to add water. If a sludge is so thick as to be non-pumpable, really that has been the only thing to do.

There is no suggestion in the prior art that it might be possible to arrive at a "mix" of temperature, pH level, and vigour of shearing, that would enable a transformation of over-10%-solids sludge from non-pumpable to pumpable.

12.2 The reason for the synergy may be explained as follows. In a sludge processing plant, a measurement of pH is a measurement of the pH of the liquid water in the sludge. Similarly, a measurement of temperature is a measurement of the temperature of the liquid water. The shearing operation breaks open whatever clumps there might be of solid (dry) material within the overall volume of the sludge being treated. If there are clumps of tightly packed solid material, the pH and temperature inside the clumps inevitably are lower than indicated by the measurements, and the larger the clumps the more likely it is that the material inside the clumps is at a lower pH and temperature than the liquid water. Thus, the more homogeneous the sludge, the more intimately the liquid water is in contact with the solids, and the more likely it is that the as-measured pH and temperature are actually measuring the overall pH and temperature.

Experts know that it cannot necessarily be expected that shearing itself will inevitably reduce

viscosity. On the one hand, shearing sludge can be like shearing an orange: the orange is transformed into orange juice, which may be regarded as less viscous than the orange. On the other hand, sludge contains many different kinds of organic molecules, locked up in the biological cells, which are released as the biological cells are torn apart. When released, these (large) organic molecules can, and in many cases do, cause the overall viscosity to increase.

However, even though shearing can cause the viscosity, as such, of the sludge to increase, still the volume of sludge material inevitably is more homogeneous than it would be if it had not been sheared. It is this homogeneousness of the sludge -- i.e the lack of pH and temperature gradients and differences over the whole volume being treated -- that enables the added alkalinity salts and the added heat to be more effective and more efficacious than they would be if the sludge were not sheared. The shearing distributes the alkalinity and the heat throughout the sludge, leaving no pockets of untreated material.

Note that mere mixing does not do this: mixing might break up the very large clumps, but mixing does not shatter every clump down to the cellular level, as does shearing.

Suppose a temperature of 55 degC and a pH of 10 are required in order to transform a particular sludge: if the sludge is not sheared, the as-measured sludge must actually be taken to e.g 75 degC and the pH to 12, and must be kept at those heights for many hours (as indicated in the Christy patents), in order for the middles of the clumps to approach those required levels. But when the sludge is sheared, now there are no middles of clumps, and the as-measured pH and temperature levels prevail homogeneously throughout the whole volume.

Thus, the sludge can be effectively treated at a lower measured pH and at a lower measured temperature, because of the shearing.

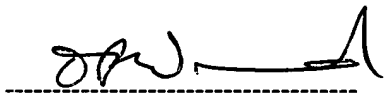
Often, the shearing does contribute directly (i.e physically) to reducing the viscosity. But the more significant function of the shearing is to homogenise the whole volume of sludge, which enables the alkalinity and heat to be more effective. This function of the shearing, which enables the alkalinity and heat to be more effective, is still present even in cases where the shearing itself has no direct physical effect on, or even increases, the sludge viscosity.

12.3
The other aspect of the synergy that arises from the combination of the invention is that the elevated pH and the high incubation temperature serve to reduce the viscosity, whereby it takes less force and energy to shear the material. Thus, provided the shearing is not started until the sludge is already hot, and already at the high pH, the reduction in viscosity attributable thereto is enough to make a worthwhile reduction in the need for robustness in the shearing machinery. A 25 kW shearing apparatus is much less expensive than a 50 kW apparatus, and that is typical of the size of the difference that can be attributed to the synergy.

12.4
All in all, the synergy permits a substantial reduction in the overall expenditure of resources that are needed to transform over-10%-solids sludge from non-pumpable to pumpable. And in many cases, the synergy enables a transformation to be made where no transformation would be possible without the synergy.

12.5
Another effect of thoroughly homogenising the sludge is that the bacteria do not quickly reappear. What can happen with traditionally treated sludges is that the bacteria residing inside the clumps might remain viable, and might re-colonise the sludge if left over a period of time (say, over a few days or weeks). But homogenised sludge tends to contain no remaining viable bacteria. We have found that the "shelf-life" of our synergistically-treated sludge can be a year or more. This can be a useful attribute in cold climates, for example, where it is impractical to apply the sludge to the fields for half the year.

13.
I hereby declare that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true: and further that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing therefrom.

Signature of Declarant: 

Date of signing: 07 May 2004
Place of signing: Waterloo, ON, Canada

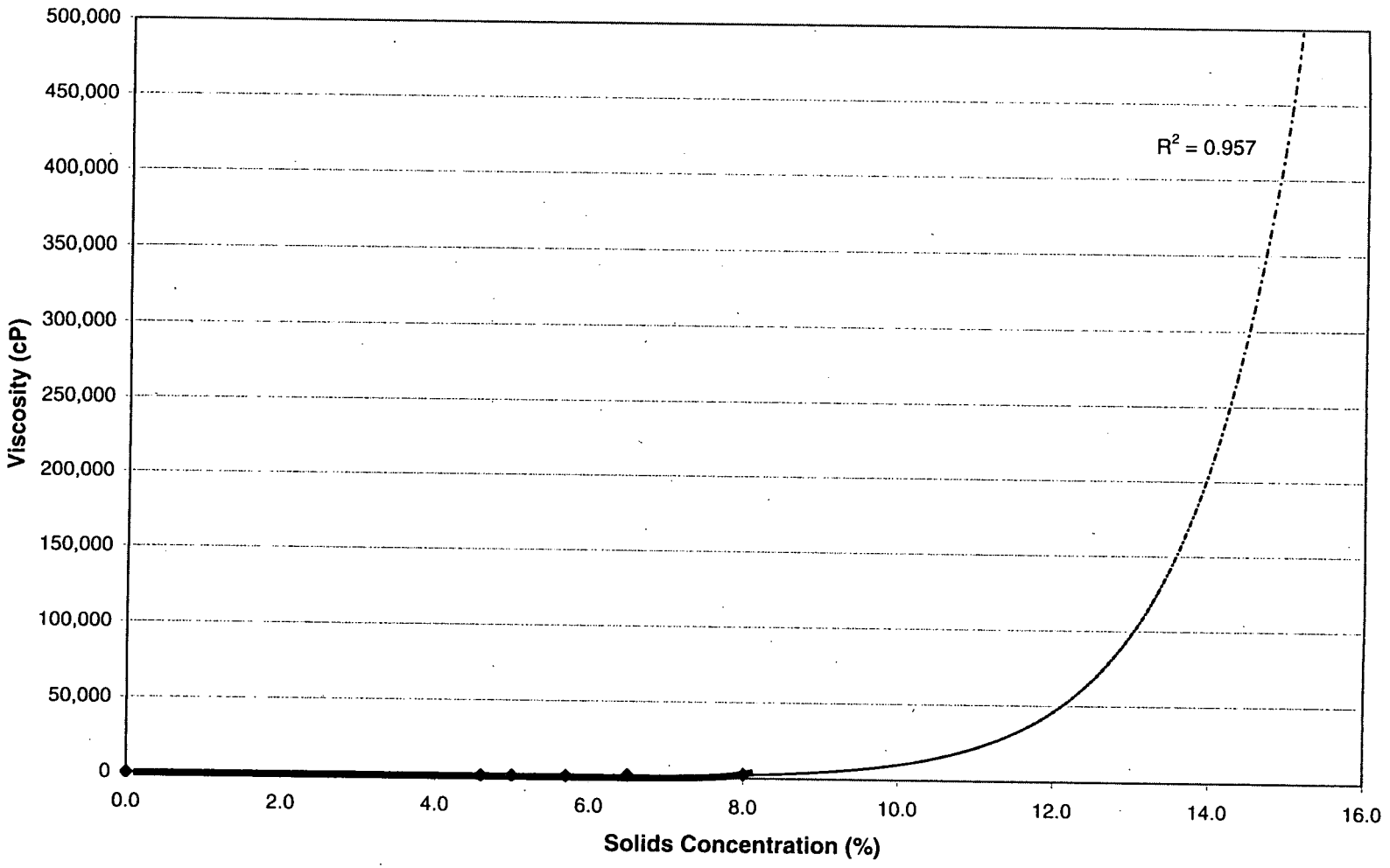


figure 4

EFFECT OF SOLIDS CONCENTRATION ON VISCOSITY OF UNPROCESSED BIOSOLIDS
DEMONSTRATION PROJECT FOR ADVANCED BIOSOLIDS MANAGEMENT PROCESS
GUELPH WASTEWATER TREATMENT PLANT
GUELPH, ONTARIO

CRA 32088 (2)

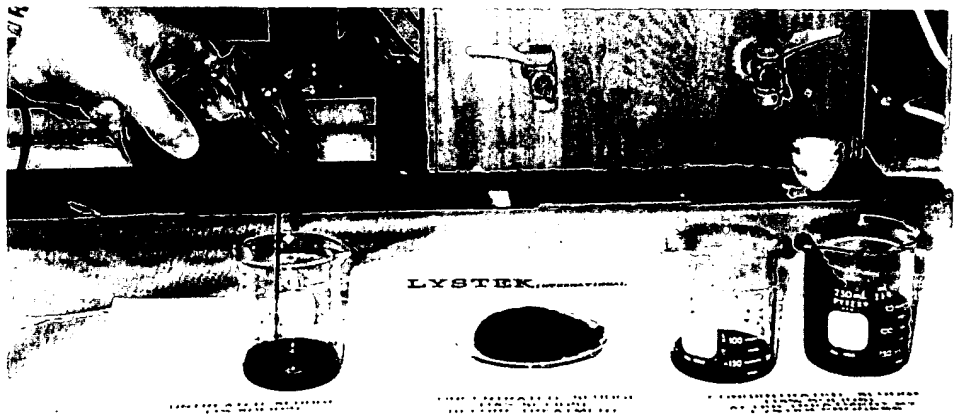
LYSTEK PROCESS FOR REDUCING VISCOSITY OF CONCENTRATED SEWAGE SLUDGE

LYSTEK INTERNATIONAL

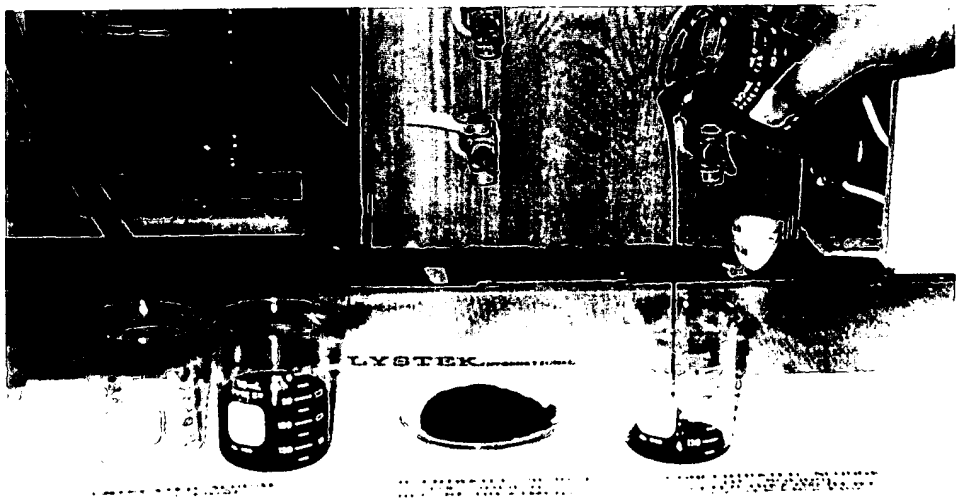
UNTREATED SLUDGE (3% SOLIDS)

CONCENTRATED SLUDGE (15% SOLIDS) BEFORE TREATMENT

CONCENTRATED SLUDGE (15% SOLIDS) AFTER TREATMENT BY LYSTEK PROCESS



POURING OF UNTREATED SLUDGE (3% SOLIDS)



POURING OF CONCENTRATED SLUDGE (15% SOLIDS) AFTER TREATMENT BY LYSTEK PROCESS

Career Profile: Prof. Owen Ward, B.Sc., Ph. D.

1970: B. Sc. Biochemistry, University College, Dublin.

1973: Ph. D. Industrial Microbiology, University College, Dublin.
Thesis: A Study of the Bacterial Extracellular Enzymes Associated with Increased Permeability of Water Stored Sitka Spruce *(Picea sitchensis)*

1973-77: Biochemical Research Technologist, IIRS-Biotechnology Unit, University College, Galway.
Highlights:
Management Function: Directed the microbiology and fermentation programme 1973-75 and headed overall unit 1975-77
Institute Sponsored Research: Developed a number of commercially viable processes for production of diagnostic enzymes
Contract Research: Developed key fermentation process for Biocon, Co. Cork.
Analytical Services: Set up client-sponsored bacteriological analytical service.

1977-80: Fermentation R & D Manager, Biocon Group (now Quest International), Co. Cork.
Highlights:
R and D Management: Directed the fermentation development programme and Biocon's laboratory R and D activity
Process Development: Developed and scaled up Biocon's first fermentation processes
Plant Commissioning: Set up and staffed Biocon's first fermentation plant.
Enzyme applications research: Established this new product development section
of the company serving subsidiaries worldwide

1980-87: Founder, Professor and Head, School of Biotechnology, NIHED/DCU, Dublin.
Highlights:
Establishment of School: Founded the School, established its physical facilities, initial staffing, teaching and research programmes
First graduate students: Registered NIHED's first graduate students in microbial and fermentation research in Fall 1981

First Ph. D graduates from NIHED: Directed and graduated NIHEDs first 2 Ph.D's. prior to the International Commission Review.
Fermentation research grants and contracts: Received some of NIHED's first industrial contracts to support fermentation research from Biocon, Ceimici Teo, Avondale Chemicals, Irish Sugar Company, International Biochemicals and awards of strategic and other research grants from NBST.
Developments in cell culture: Appointed Ireland's first lecturer in cell culture/paved way

for the National Centre in Cell and Tissue Culture
Biotechnology Degree: Established NIHED's B. Sc. in Biotechnology, integrating biology and process engineering. This was Ireland's first B. Sc. in Biotechnology.

Appointments: Member of NIHED Governing Body, 1982-1987; Member of Institute Executive, 1980-86: Dean of Science, 1985-86; Chairman of B. Sc in Biotechnology Course Board; Member of Royal Irish Academy's National Committee for Biology, 1984-86 and National Commission for Microbiology, 1982-86; Member of the Higher Education Authority Advisory Committee on Biotechnology, 1981-86; Member of the Food Working Group, National Biotechnology Coordinating Committee, 1984-86. Member of Department of Industry Working Group on Funding of Research for Product Innovation and Development by Third Level Institutions, 1984: Member of NCEA Board of Assessors, Biological Sciences1982-86; NCEA External Examiner.

1987-Present: Industrial Research Professor of Microbial Biotechnology, University of Waterloo
Highlights:
Microbial Biotechnology Laboratory (MBL): Established and directed the MBL, including a well equipped fermentation R & D facility.
Research Funding: Attracted millions of dollars from government agencies NSERC, NRC and URIF, CREST and from fermentation and biotechnology companies including: Allelix Biopharmaceuticals, Toronto: Seagram, Montreal; Apotex,Winnipeg; Hygrex-Spehr, Toronto; Nestle, New York; Biorem Technologies; Petrozyme Technologies; Lystek International.
NSERC Industrial Research Chair: Was awarded this endowed research chair, held for the maximum period of 2 x 5 years.
Associate Director of National Research Network (CELNET) funded by Natural Sciences and Engineering Research Council of Canada, Canadian Pharmaceutical Companies and the Biotechnology Research Institute (NRC), 2003-.
Publications: Published more than 170 peer reviewed research publications in Fermentation, Microbiology and Enzyme Technology, many more abstracts, many book chapters and three books.
Patents: Co-authored 7 recent patent applications. Presented research/expert papers at symposia on experiences with patenting research results and intellectual property management, commercialisation and protection.
Editorial boards: Section Editor, Can. J. Microbiol, 1994-97; Member of the editorial board of J. Industrial Microbiol. Biotechnol (1994-); Member of the editorial board(1995-99) and Assistant Editor (2000-) World J. Microbiol. Biotechnol.
Ph. D. External Examiner: Served as external examiner for Ph.D students in various countries.

Academic Appointment Boards: Served on many academic appointment boards at professorial and other levels including:
Director of University of Waterloo Science and Business Programmes: (June 2005-).
Executive personnel training: Placed senior postdoctoral researchers from MBL in key technical management positions in many Canadian and US Biotechnology companies.

Mentoring: Established the mentoring programme "Let's Meet" for Biology undergraduates (1997-) and became Director of the programme.
Undergraduate officer: For Biochemistry Programme (2001-)
Undergraduate teaching: Developed and taught B-443:Fermentation Biotechnology every year, 1987-Present, consistently receiving excellent teaching evaluations from the class, with several nominations for the Distinguished Teachers Award. Developed and taught B-474:Bioprocessing for 2001-onwards.
President of the Canadian Society of Microbiologists(CSM): Elected 1996-97 Reorganised the management of the Society, brought the budget into the black for the first time in 10 years, increased Society membership by 20%after 5 years of decline
Canadian Microbiology Graduate Student of the Year Award: Established award in 1997 and act as co-ordinator of the International Scientific Review Committee
Director of the Society of Industrial Microbiology(SIM) (US): Served 1995-98.
Joint Annual Meeting of CSM/SIM: Organised the first joint annual meeting of the Societies in 1994.

Other appointments and committees: Adjunct Professor, Department of Food Science, University of Guelph, 1992-1999; Served on a variety of committees including: Biology Promotions and Tenure Committee; Science Faculty Strategic Planning Committee; NSERC's Biotechnology Strategic Grants Committee, 92-95 and Chairman in 1995; NSERC Strategic Implementation Task Force, 1995; NRC's Biotechnology Research Institute Research Advisory Council 1998- Present: Director of Guelph-Waterloo Biotech,1987-91.
Technology transfer: Technology developed at MBL has been transferred to a variety of Canadian and US companies.This included commercialization of a fermentation process to produce human epierrmal growth factor (h-EGF) by Allelix Biopharmaceuticals, production of other human hormones by recombinant Aspergillus and E. coli and an enzyme-based process for increasing ethanol production in rye whiskey fermentations for Seagrams. Research from my laboratory also resulted in the creation of three spin-off companies, Biorem Technologies, Petrozyme Technologies and Lystek International.

1991-99: Founder of Biorem Technologies Inc. (President 1991-94; Chairman 1991-99).
Highlights:
Company activity: develops and implements processes for bioremediation of

contaminated soil, water and air. Has completed projects in Canada and the US for companies including Monsanto, Akzo-Nobel, Polysar, Regallite, Maple Leaf, Uniroyal, Ultramar; printed circuit board manufacturers, food processing and pet food companies; animal feed manufacturers; composters and municipalities. The company recently installed a biofilter for the City of Toronto and has about 80 installations across North America.
Lead Products/Processes: Modular biofilter and second generation high capacity biofilter ***Acquisitions and partners:*** Recently acquired a US company. ***Current status:*** Profitable company doubling its sales annually on average (past 3 years). Thus company is a market leader in biofilters in North America, with about 70 installations.
(See Website www.bioremtech.com).

1996-Present: Founder, Chairman and President of Petrozyme Technologies Inc.
Highlights:
Company activity: develops and implements bioreactor-based processes for biotreatment of high volume petroleum wastes from refineries and oil exploration and production operations. Completed first full scale contract for Venezuela's National Oil Company, PDVSA, at a bioreactor scale of one million litres. Process has been used for four years to biodegrade oily from 70% of Venezuela's refining capacity. Petrozyme's technology is being considered for application to clean up more than 15000 large oil lagoons from Venezuela's past oil exploration and production activities. Completed first Pilot project for Mexico's National Oil Company, PEMEX. Pilot projects have been completed at Shell, Montreal and PetroCanada Ontario, and at a number of US refineries. The Petrozyme bioreactor process is the only biological process which converts US refinery oil sludges from hazardous to non-hazardous, according to US EPA criteria. The company has recently been awarded contracts in Malaysia and Saudi Arabia (Saudi Aramco).
Marketing activities worldwide; 5 patents granted/pending.

1999-Present: Founder, Chairman and Technical Director of Lystek International Inc.

Highlights:
Company Activity: develops and implements biological and other technologies for processing of high volume biological wastes, specifically human and agricultural biosolids. Processes focus on cost effective reduction of volume and solids content, viscosity reduction, removal of pathogens, reduction of vector attraction properties, reduction of odors and development of dry slow release fertilizer applications with improved safety.
Partners: Regional Municipality of Waterloo; Conestoga Rovers Inc.(Engineers); Energy Group, NZ. Terratek (American Water).
Current Status: The first process (patent pending) was successfully scaled up and demonstrated at the Guelph, Ontario Municipal Treatment Plant in 2003. Feb 2004:

Guelph has awarded Lystek with its first production contract. Other processes are under development.

PROFESSOR OWEN P. WARD

Main Scientific Achievements:

1. Decarboxylases in asymmetric synthesis:

-First to report asymmetric acyloin synthesis by benzoylformate decarboxylase, with characterisation of biotransformation conditions and enantiospecificity.

-Comprehensively characterised biotransformation for pyruvate decarboxylase-mediated acyloin formation, including cosubstrate specificity, dehydrogenase-catalysed by-product formation, aldehyde toxicity and biocatalysis in non-conventional reaction media,

2. Omega-3/6 fatty acid production:

-First to characterise culture conditions for production of docosahexaenoic acid (DHA,22:6) by *Thraustochytrium* species, which produce >50% of fatty acids as DHA.

-Provided comprehensive characterisation of physiology of omega-3 production by *P. tricornutum.*

-Described optimised culture conditions for arachidonic acid (AA) production by *Mortierella* species.

3. Fermentation research:

Completed the basic research on production of B-1,3-glucanase by *P. emersonii.* Developed and scaled up this process as Biocon's (Quest International) first fermentation process. Implemented R&D programmes to develop fermentation processes using recombinant .and non-recombinant .strains for companies in Europe and North America.

4. Biodegradation research:

My research in environmental biotechnology has lead to the development and scale-up of processes for biodegradation of recalcitrant chemicals, refinery petroleum sludges and human and animal biosolids.

These processes have resulted in the establishment of three spin-offs (see below).

5. Interdisciplinary Research: Process Development:

Collaborations involving development, evaluation and application of process equipment and systems for materials handling, dewatering, low energy drying, flocculation, solids/liquid separation, gasification, ethanol synthesis, bioreactor and bioprocess design and scale-up. Large-scale process implementation:

RECENT ACKNOWLEDGEMENTS:

Award Nominee: Canadian Government nominated me for the 2002 Blue Planet Prize, the international environmental award for outstanding achievements in research.

Citation: Our paper No.134 below (Ward, O.P. and M. Baev. 1999. Decarboxylases in stereoselective catalysis) was cited as *'of outstanding interest'* by Current Opinion in Biotechnology, 2000, Vol 12, p604.

Recent Review: Invited to author review in the number 1 microbiology journal based on impact factor on "Recent Advances in Petroleum Microbiology" for MMBR Microbiological and Molecular Reviews, (2003), 503-549.

Teaching Award: Nominee for the 2004 University of Waterloo Distinguished Teaching Award.

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